Section 3

3. ETMS Traffic Flow Analysis

This section identifies the ETMS data flows between ETMS-enabled facilities. It defines each type of data exchange and its respective size and frequency. Consequently, this section identifies the major flows which constitute the largest traffic volume on the system.

3.1 ETMS Data Flows

As explained in Section 2.1, there are 85 ETMS-enabled sites within FIRMNet. These 85 sites include VNTSC, the ATCSCC, the WJHTC, FAA Academy, 21 ARTCCs, 37 TRACONs, 7 ATCTs, 3 CERAPs, 8 regional offices, and 5 military or other facilities. Figure 3-1 summarizes each of the ETMS data flows and the origination and the destination of each flow.

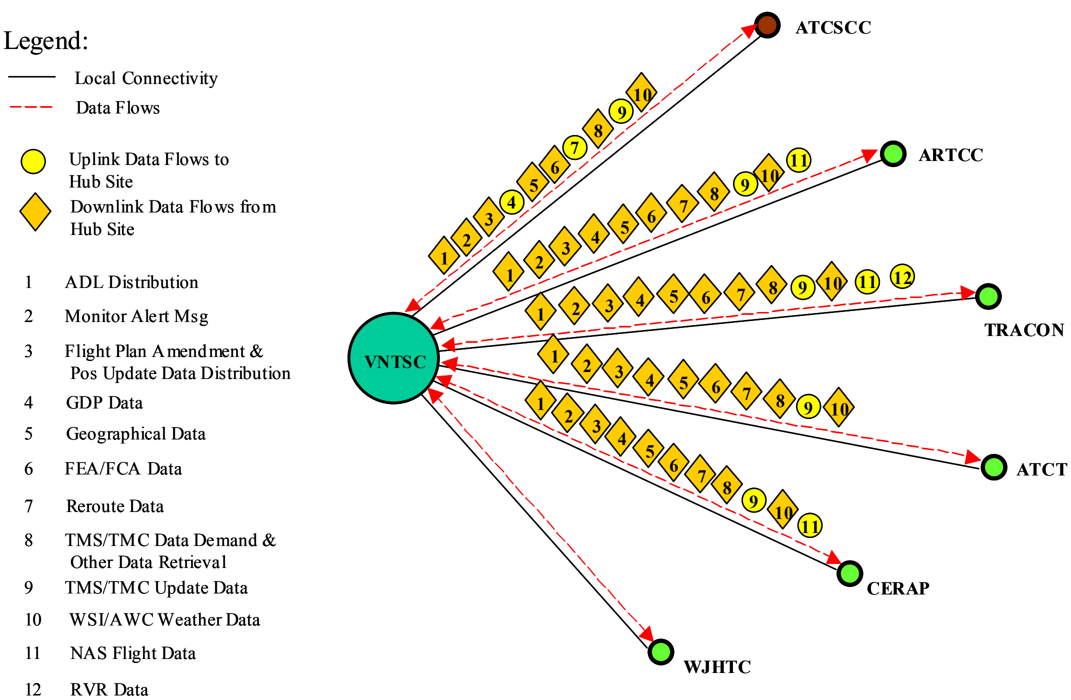

Figure 3-1: ETMS Data Flows

As indicated in Figure 3-1, all of the ETMS data flows, with the exception of TMS/TMC Update Data (#9), NAS Flight Data (#11), and Runway Visual Range (RVR) Data (#12), are completely downlink data flows, meaning they flow from VNTSC to the TMUs. Two data flows, GDP Data (#4) and Reroute Data (#7), are characterized as uplink data flows from the ATCSCC to VNTSC. They are then characterized as downlink data flows from VNTSC to the other TMUs. Overall, the total size of downlink data flows constitutes more than 90 percent of the total ETMS traffic flow.

3.2 ETMS Traffic Data Sources

To calculate the traffic generated by each of the data flows, data was collected from multiple sources. Original ETMS data was collected from the ATCSCC for the following data flows and on the indicated dates:

- NAS Flight Data recorded between October 31, 2002, and November 13, 2002
- Flight Plan Amendment and Position Update Data Distribution recorded between October 31, 2002, and November 13, 2002
- Weather Data from recorded between October 31, 2002, and November 13, 2002
- Fuel Advisory Delay Tables (FADT)/Ground Delay Program (GDP) Files recorded November 22, 2002
- Monitor Alert Data recorded between October 31, 2002, and November 13, 2002 (November 2, 2002, was missing from the data set)
- Geographical Data recorded November 26, 2002
- ETMS Data Statistics recorded September 4, 2002.

Other information sources obtained from the FAA and used in this analysis also include the following:

- ETMS utilization traffic rate profiles dated November 15, 2001
- *Preliminary TFM/CRCT Integration Performance Analysis*, MITRE Corp., dated November 2001
- ETMS Interface Control Documents (ICD)
- ETMS Functional Description dated June 2002
- ETMS Functional Audit dated November 2002.

Although a significant amount of data was collected, some of the sources contained incomplete data flow information. Specifically, the Monitor Alert Data set contained complete data for only 6 consecutive days. Additionally, some messages within Flight Data Distribution and NAS Flight Data such as CRL, TTM, and CRI, also were incomplete. However, despite these shortcomings, substantial data for eight of the 12 data flows was processed and analyzed.

3.3 ETMS Data Flow Analysis

For each ETMS data flow for which raw data was received from the ATCSCC, a statistical analysis was performed. Specifically, the mean and standard deviation of the size and the frequency of each flow was calculated. In doing so, a range in which a predominant number of the data points lie is provided. For example, 68 percent of data points lie within one standard deviation of the mean and 95 percent of data points lie within two standard deviations of the mean. Thus, calculating a range allows for a more complete analysis of the size and frequency of each flow. The results of these analyses are discussed in the following sections.

3.3.1 Monitor Alert Distribution

Thirteen days of Monitor Alert Data were obtained from the ATCSCC. However, of these 13 days, only 6 days contained complete data sets and 7 days contained partial data sets. Despite these shortcomings, more than 9,000 data points were used in this analysis.

Monitor Alert Data is composed of three separate files: A, F, and S. Each minute, A, F, and S files are sent automatically from VNTSC to the TMUs. It was assumed that these three files are sent together as one large file per minute. Analysis results reveal that the mean Monitor Alert file size is 173 KiloBytes (KB) and the standard deviation is 10KB. Thus, approximately 68 percent of the Monitor Alert data flows range between 163KB and 183KB and approximately 95 percent of the Monitor Alert data flows range between 153KB and 193KB. Figure 3-2 shows the variation in the size of Monitor Alert Data throughout a single representative day. Analysis of the data set revealed that the size of Monitor Alert Data follows a pattern throughout the day. At approximately 0000Z, a continual decrease in the size of the data occurs, which increases again at approximately 1000Z. Because the Monitor Alert Data is transmitted every minute, the frequency is constant and thus, is not shown in the figure.

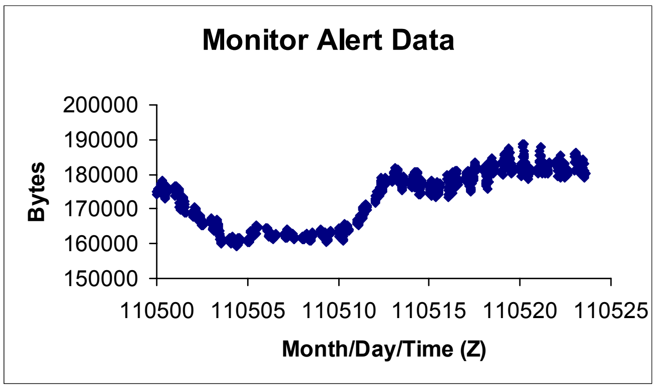

Figure 3-2: Monitor Alert Data – Sample Day

3.3.2 Flight Plan Amendment And Position Update Data Distribution

Flight Plan Amendment and Position Update Data Distribution (referred to as Flight Data Distribution for the remainder of this document) is composed of numerous flight messages batched together into a single packet. According to the concept of operations (CONOPS), flight data messages are collected at VNTSC, and the packet is sent to the TMUs once the packet size reaches 7.7KB or 5 seconds have passed since the last distribution.

The Flight Data Distribution statistical analysis used 14 days of data. The mean packet size was calculated to be 7.6KB with a standard deviation of 0.1KB. As for the time between packets, the mean inter-arrival time is 3 seconds and the standard deviation is 2 seconds. Figure 3-3 shows the pattern of the Flight Data Distribution packet size and inter-arrival time throughout a sample day. The packet size depicted in this figure represents the total size of all the packets transmitted throughout the hour.

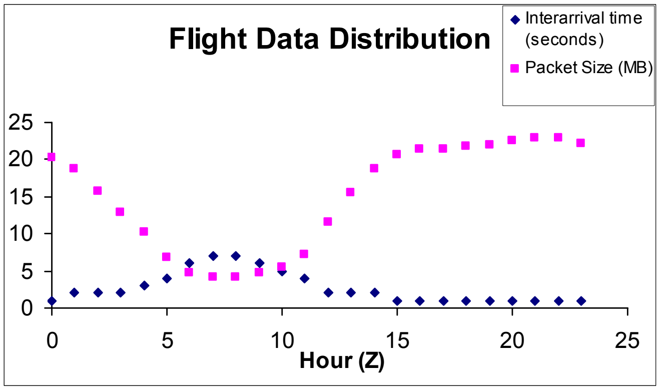

Figure 3-3: Flight Data Distribution – Sample Day

In Figure 3-3, the series of pink squares represent the packet size in Megabytes (MB), while the blue diamonds represent the inter-arrival time in seconds. To interpret the graph, consider the data points that correspond to 0500Z; the packet size at 0500Z is 7 MB while the inter-arrival time is 5 seconds. This convention is used for all remaining figures in this sub-section.

Looking at the graph, the total amount of Flight Data distributed to the TMUs decreases between 0000Z and 0700Z and increases again after 0800Z. In addition, the time between transmissions is highest between 0400Z and 1100Z each day. Lastly, Flight Data Distribution size and frequency is at its peak between 1900Z and 2200Z everyday.

The following sub-sections detail each of the messages that are encompassed within each flight data packet.

3.3.2.1 AIR

Based on collected data, it was determined that each AIR message is constant at 66 Bytes. Additionally, the mean inter-arrival time between AIR messages is 1 second with a standard deviation of 0.6 seconds. Figure 3-4 shows the message size and inter-arrival time of AIR messages for a sample day. As shown in the graph, it is apparent that there is a steady increase in inter-arrival time between 0000Z and 0600Z. After 0600Z, it begins to decrease until 1400Z, where it holds steady until 2300Z.

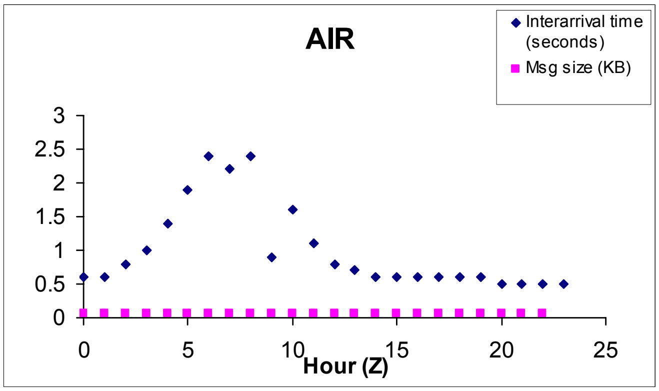

Figure 3-4: AIR Message – Sample Day

3.3.2.2 ALT

Similar to AIR messages, the frequency of ALT messages varies throughout the day, whereas the size remains constant at 30 Bytes. The mean inter-arrival time between ALT messages is 17 seconds and the standard deviation is 33 seconds. Thus, the frequency of these messages varies greatly throughout the day. Figure 3-5 reveals the size and frequency of ALT messages throughout a sample day. According to the figure, the inter-arrival time between ALT messages increases between 0800Z and 1100Z, then decreases sharply thereafter. For the remaining times of the day, the frequency remains fairly steady.

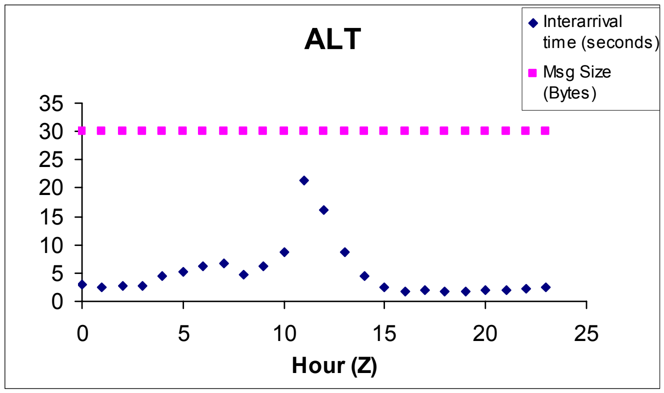

Figure 3-5: ALT Message – Sample Day

3.3.2.3 CAN

CAN messages have a fixed size of 22 Bytes and the time between transmissions varies throughout the day. Although the message size is fixed, the frequency of transmission varies greatly with a mean of 29 seconds and a standard deviation of 60 seconds. Figure 3-6 represents the size and frequency of CAN messages throughout a sample day. As shown in the figure, there is an increase in inter-arrival time between 000Z and 0600Z. After 0600Z, it experiences a steady decrease until approximately 1200Z. Between 1200Z and 2300Z, the inter-arrival time remains fairly constant.

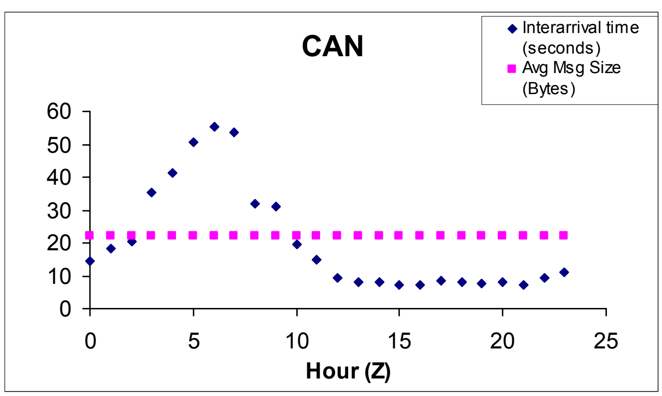

Figure 3-6: CAN Message – Sample Day

3.3.2.4 CRI

CRI messages[1] have a fixed size of 92 Bytes and a mean inter-arrival time of 138 seconds. In addition, based on the data set that was provided, the frequency of CRI messages has a standard deviation of 259 seconds.

3.3.2.5 CRL

CRL messages[2] have a fixed size of 48 Bytes and a mean inter-arrival time of 118 seconds. Using the given data set, the analysis revealed that the frequency of CRL messages varies greatly throughout the day. The calculated standard deviation of the frequency of these messages is 334 seconds. Figure 3-7 reveals the size and frequency of CRL messages throughout a sample day. Since the data used for this analysis was incomplete, patterns in the frequency of CRL messages is undetectable.

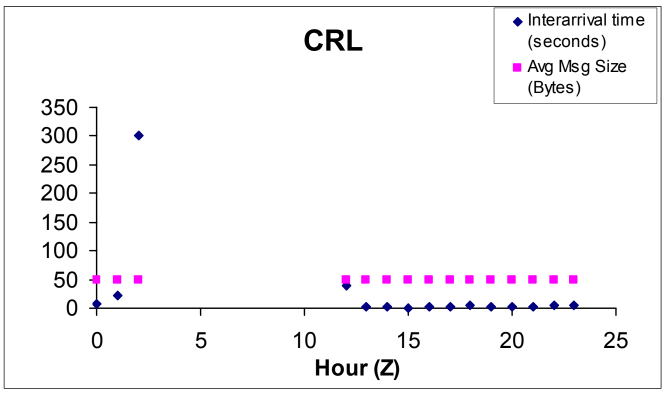

Figure 3-7: CRL Message – Sample Day

3.3.2.6 POS

Similar to other Flight Data Distribution messages, POS messages have a fixed size while the frequency of these messages varies throughout the day. Specifically, POS messages are constant at 66 Bytes and the mean inter-arrival time is 24 seconds with a standard deviation of 10 seconds. Figure 3-8 reveals the size and frequency of POS messages throughout a sample day. As shown in the figure, the frequency of POS messages experiences peaks and troughs throughout the day. According to the sample data, peaks are experienced at approximately 0800Z and 2300Z, whereas troughs occur at 0300Z and 1500Z.

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[1] CRI messages were present only between November 11, 2002, and November 13, 2002. In addition, these 3 days of data were incomplete.

[2] CRL messages were unavailable between the hours of 0300Z and 1100Z every day.

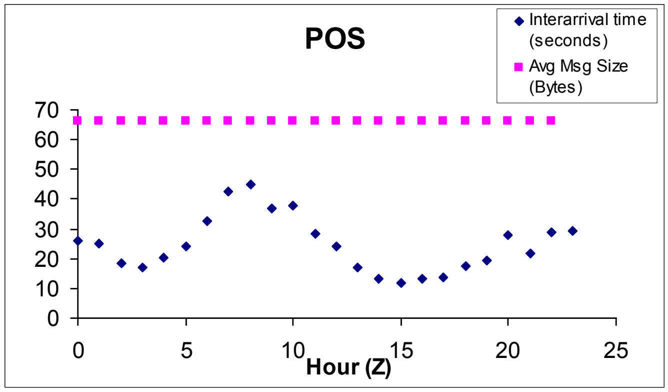


Figure 3-8: POS Message – Sample Day

3.3.2.7 ROU

The size and frequency of ROU messages varies throughout the day. The mean size of ROU messages is 294 Bytes and the standard deviation is 12 Bytes. With respect to frequency, the mean inter-arrival time of ROU messages is 0.64 second and the standard deviation is 4.7 seconds. Comparing the size and frequency of this message with other Flight Data Distribution messages, it is apparent that ROU messages comprise a large portion of the flight data packets.

The graphs shown in Figure 3-9 reveal the variation in size and inter-arrival time of ROU messages throughout a sample day. As shown in both graphs, the size of the messages and the inter-arrival time follow a pattern throughout the day. With respect to message size, the ROU messages peak at 0000Z. The message size then steadily decreases from 0600Z to approximately 1000Z, at which point, it steadily increases again until 0000Z. Regarding the frequency of the messages, the inter-arrival time experiences a peak between the hours of 0600Z and 0800Z and decreases steadily after that point until 0000Z.

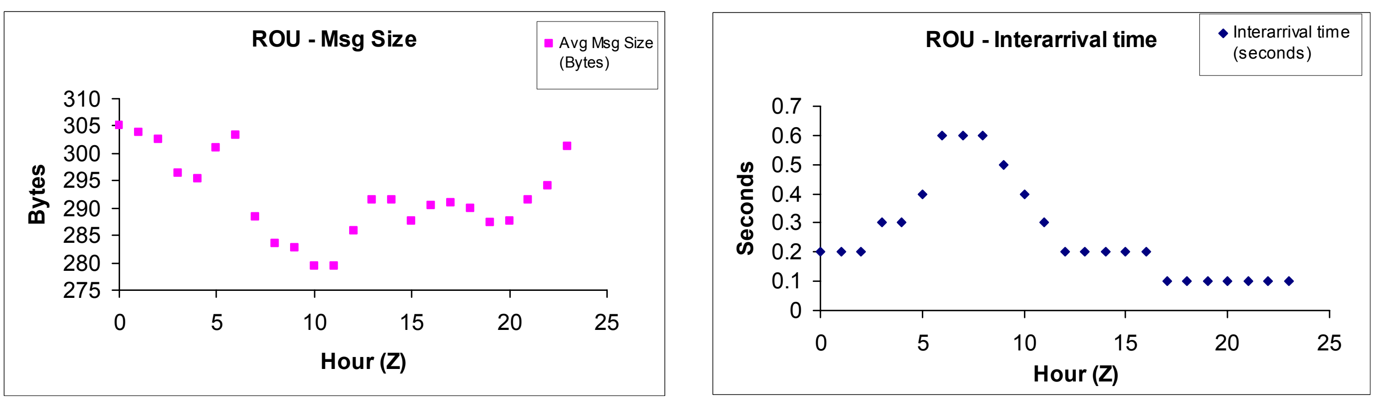


Figure 3-9: ROU Message – Sample Day

3.3.2.8 TIM

TIM messages have a fixed size of 54 Bytes; however, the inter-arrival time of the messages varies throughout the day. The mean inter-arrival time of TIM messages is 0.76 second with a standard deviation of 0.8 second. Figure 3-10 represents the size and frequency of TIM messages throughout a sample day. As shown in the figure, as the size of the messages remains constant, the frequency of the messages varies. The inter-arrival time experiences a peak at approximately 0800Z, at which point it steadily decreases until 2300Z.

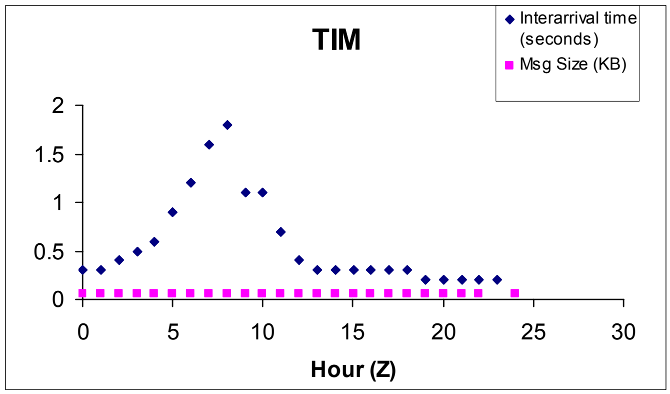


Figure 3-10: TIM Message – Sample Day

3.3.2.9 TTM

TTM messages are another flight data message type whose size and inter-arrival time vary throughout the day. The mean TTM message size is 343 Bytes with a standard deviation of 89 Bytes. Although the size of TTM messages is large in comparison to other flight data messages, the frequency of TTM messages is fairly low that is, there is a long duration between messages. The mean frequency is 1,073 seconds with a standard deviation of 1,216 seconds. Figure 3-11 shows the size and frequency of TTM messages throughout a sample day. As shown in the figure, unlike other flight data messages, TTM message sizes and frequencies do not appear to follow a pattern.

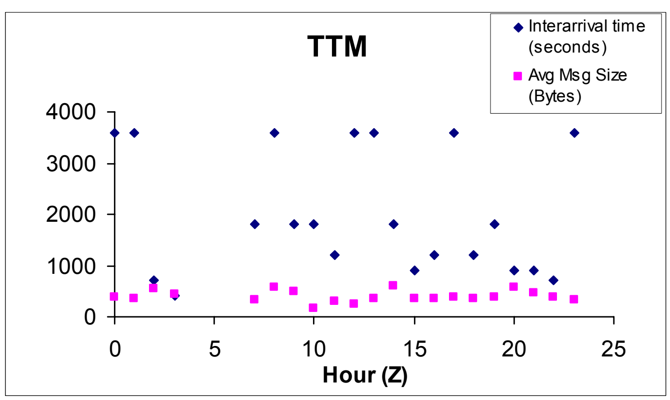


Figure 3-11: TTM Message – Sample Day

3.3.2.10 TZ

TZ messages, which have a fixed size of 44 Bytes, have the highest frequency rate with an average inter-arrival time of 0.02 seconds. Although the size of these messages is not large, they comprise the largest portion of the flight data packets as a result of their high frequency rate. Figure 3-12 reveals the size and frequency rate of TZ messages throughout a sample day. As shown in the following figure, the frequency of TZ messages peaks between 0500Z and 1000Z.

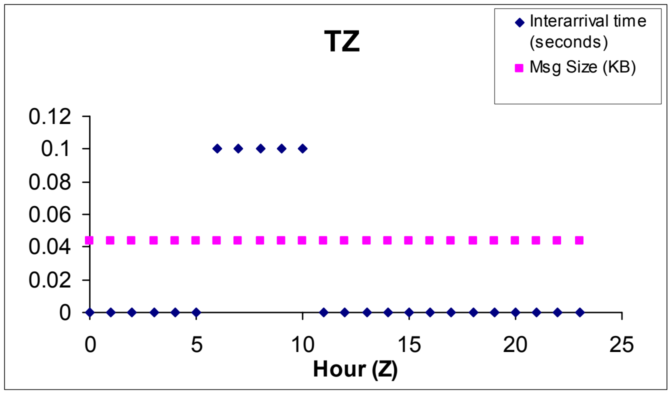


Figure 3-12: TZ Message – Sample Day

By examining each of the messages that comprise a Flight Data Distribution packet, the messages that generate the largest amount of traffic can be determined. In Figure 3-13, the hourly average traffic rate (HATR) for each flight data message are calculated and summed for an average given day. The HATR indicates the volume of traffic transferred during an hour. Examining HATR over a 24-hour period reveals the traffic volume profile and peak hours of the flow. By analyzing the aggregate flight data messages, it appears that TZ and ROU messages comprise the majority of the traffic within flight data packets sent from VNTSC to the TMUs.

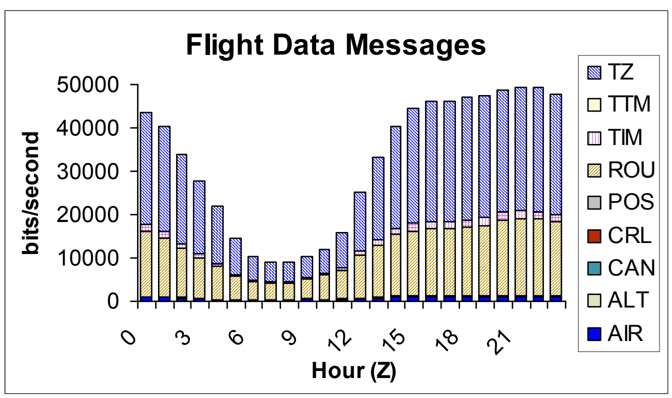


Figure 3-13: Hourly Average Traffic Rate of Flight Data Messages – Sample Day

3.3.3 GDP Data

The GDP data analyzed for the ETMS traffic analysis is composed of FADT file statistics from the ATCSCC. However, only 1 day's worth of FADT files was provided. Figure 3-14 reveals the size and frequency of the FADT files sent to VNTSC from the ATCSCC on November 22, 2002. Using this data set, the mean FADT file size is 129 KB with a standard deviation of 56 KB. Since the GDP data flow is event based rather than time based, there is no pattern in the inter-arrival time of the FADT files.

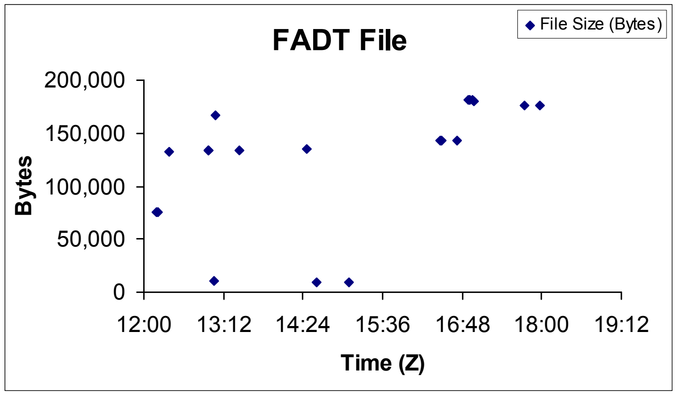


Figure 3-14: GDP Data

3.3.4 Geographical Data Distribution

The geographical data is received at VNTSC every 56 days from various sources and is distributed to the TMUs. The sources of geographical data are as follows:

- Adaptation Controlled Environmental Systems (ACES) of the 20 ARTCCs
- National Ocean Service (NOS) of the National Oceanic and Atmospheric Administration (NOAA)
- National Flight Data Center (NFDC) of the FAA
- Owner and operator of Canada's civil air navigation service (NAV Canada) and Canadian ETMS Sites.

ETMS takes the data from these sources and produces databases, reports, and map overlays for use of the traffic managers over the Traffic Situation Display (TSD).

According to statistics from the ATCSCC, the geographical data file sent to the TMUs every 56 days is sent in the form of compressed 8.18 MB .tar files.

3.3.5 WSI/AWC Weather Data Distribution

The ETMS hubsite, located at VNTSC, receives weather data from Weather Services International (WSI) and makes it available mostly through the TSD. The WSI data includes:

- Aviation Routine Weather Report (METAR) - received every 10 minutes
- International Aerodrome Forecast (TAF) - received every 10 minutes
- Grid winds - received every 3 hours
- Nowrad2km - received every 5 to15 minutes
- Radar tops - received every 10 minutes
- Lightning - received every 5 minutes.

Once this data is received at the hubsite, it is automatically forwarded to the other TMUs.

Weather data statistics recorded on September 4, 2002, and October 31, 2002, through November 13, 2002, were received from the ATCSCC for the following weather data types: Jet Stream, Nowrad2 (Canada and San Juan), Nowrad6 (Canada and San Juan), Echo Tops, Collaborative Convective Forecast Product (CCFP), and Lightning. The results of the traffic analysis on each weather data type are detailed in this section.

3.3.5.1 Jet Stream

According to statistics from the ATCSCC, Jet Stream data is transmitted to the TMUs every 3 hours. In addition, the average size of Jet Stream data is 49 KB and the standard deviation is 3KB. During the 2-week period that the data was recorded, the size of the files followed a steady curve as shown in Figure 3-15.

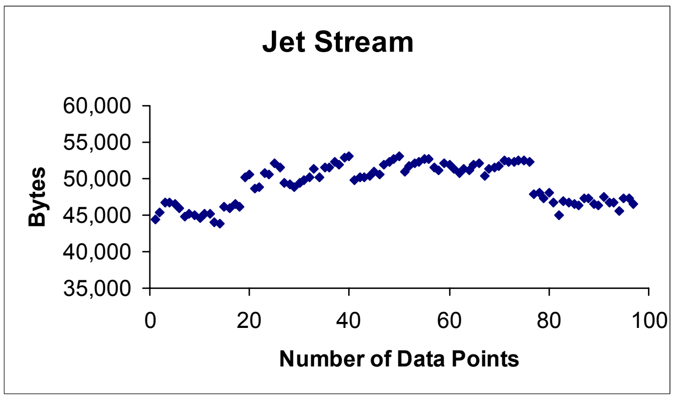


Figure 3-15: Jet Stream Data

3.3.5.2 Nowrad2

Three types of Nowrad2 data are sent from VNTSC to the TMUs: Nowrad2 (containing U.S. data), Nowrad2 Canada, and Nowrad2 San Juan. Nowrad2 data is transmitted every 5 minutes, whereas Nowrad2 Canada and Nowrad2 San Juan are sent every 15 minutes. The average size of Nowrad2 data is 134KB with a standard deviation of 38KB. Figure 3-16 shows recorded Nowrad2 data between October 31, 2002, and November 13, 2002.

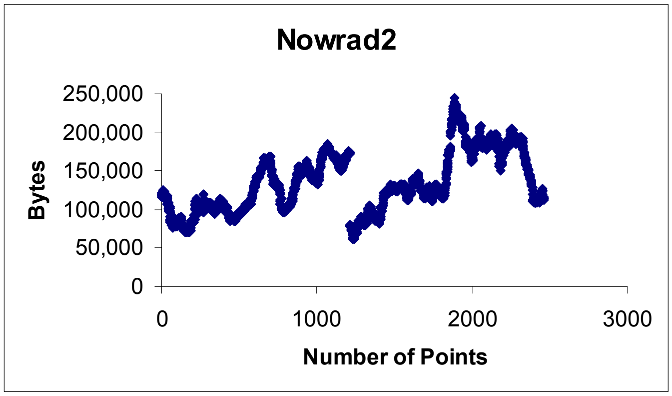
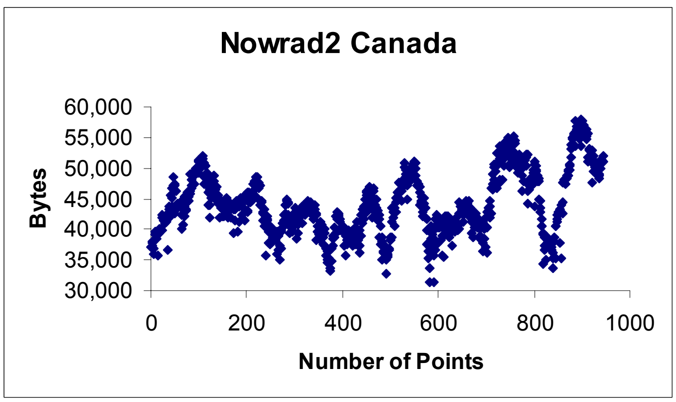


Figure 3-16: Nowrad2 Data

Nowrad2 Canada has a mean of 44 KB and a standard deviation of 5KB and Nowrad2 San Juan has a mean of 7KB and a standard deviation of 2KB. The graphs in Figure 3-17 illustrate the recorded data for these two weather data flows.



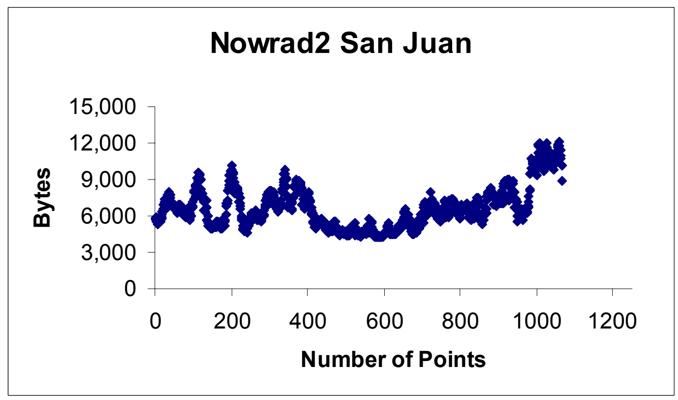


Figure 3-17: Nowrad2 Canada and San Juan Data

3.3.5.3 Noward6

Similar to Nowrad2 data, there are three types of Nowrad6 data: Nowrad6 (containing U.S. data), Nowrad6 Canada, and Nowrad6 San Juan. However, not all Nowrad6 data is sent to all TMUs; instead, it is sent to only select locations such as ATCSCC and WJHTC. Furthermore, it is sent to all TMUs only if Nowrad2 data is unavailable.

According to the data recorded from October 31, 2002, and November 13, 2002, the mean of Nowrad6 data is 33KB and the standard deviation is 12KB. This data set is sent every 5 minutes from VNTSC. Figure 3-18 shows the size of Nowrad6 during the 14-day period.

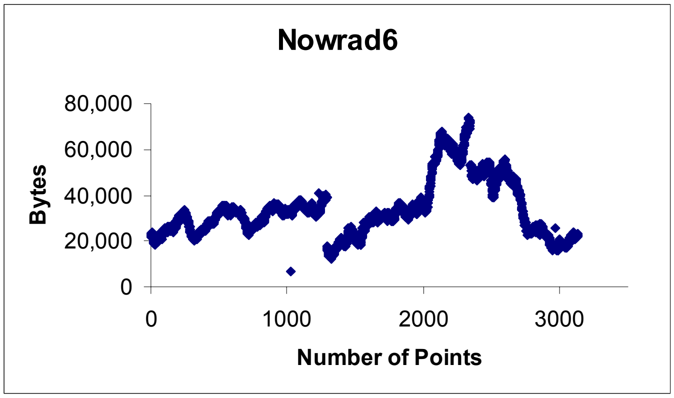
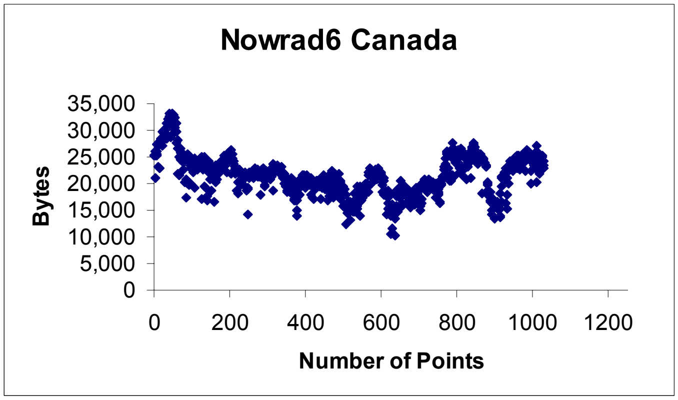


Figure 3-18: Nowrad6 Data

Statistics for Nowrad6 Canada and San Juan were also recorded. Analysis reveals that the mean of Nowrad6 Canada data is 22KB with a standard deviation of 4 KB, whereas Nowrad6 San Juan has a mean of 4KB and a standard deviation of 2KB. The graphs in Figure 3-19 show the size of these two files over the 14-day period.



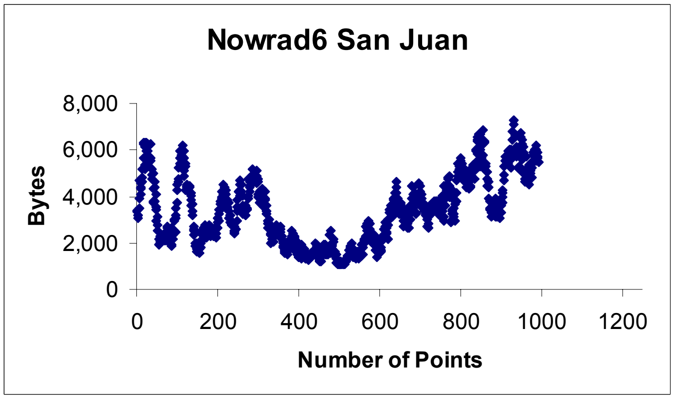


Figure 3-19: Nowrad6 Canada and San Juan Data

3.3.5.4 Echo Tops

Echo Tops data is sent from VNTSC to the TMUs every 10 minutes. Over the 2-week period that data was collected, the data size of Echo Tops was either 1.5KB or 2 KB. There also appeared to be no discernible pattern in the data size. The following graph shows the size of Echo Tops data between October 31, 2002, and November 13, 2002.

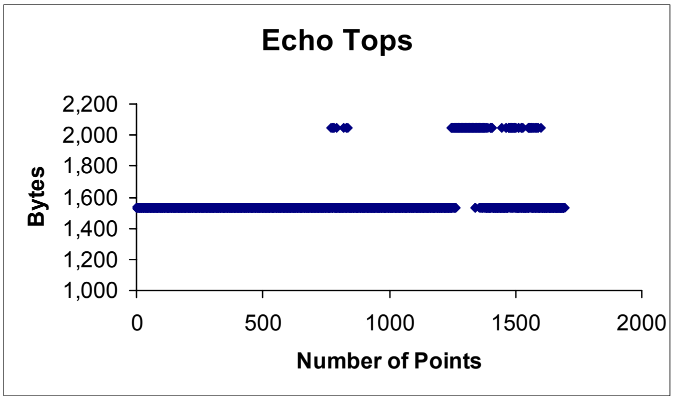


Figure 3-20: Echo Tops Data

3.3.5.5 Collaborative Convective Forecast Product

CCFP is received from the Aviation Weather Center (AWC) during the severe weather season, which occurs between April and October. The statistics used for this analysis is based on data from the ATCSCC recorded on September4, 2002. Using this data, the mean CCFP data size is 1KB with a standard deviation of 0.5 KB.

3.3.5.6 Lightning

Lightning data is sent from the VNTSC to the TMUs every 5 minutes. Between October 31, 2002, and November 13, 2002, lightning data averaged 250 Bytes and varied greatly with a standard deviation of 605 Bytes. Figure 3-21 reveals the size of the lightning data during the 14-day period. As shown in the graph, a large spike occurred in the lighting data files, which most likely resulted from bad weather in some regions of the country.

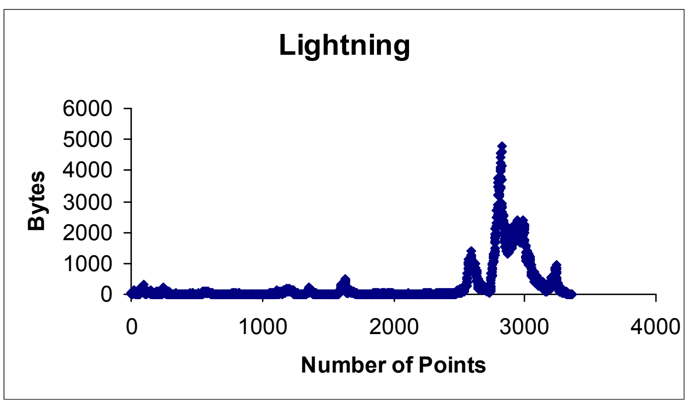


Figure 3-21: Lightning Data

3.3.6 NAS Flight Data (uplink)

The NAS host computers, which are located at the ARTCCs, generate messages based on air traffic control data such as flight plans, departures, and arrivals. Additional sources of NAS messages data are sent from select TRACONs and CERAPs. This uplink message data is carried on ETMS FIRMNet. Thirteen different messages are sent from the ARTCCs to VNTSC. Unlike the downlink data flows described previously, the frequency at which these NAS Flight Messages are sent differs for each site. For example, ARTCCs with higher amounts of air traffic will generate more NAS Flight Messages than ARTCCs with less air traffic. To handle the differences across ARTCCs, TRACONs and CERAPs, all of the data sources were ranked based on the amount of NAS Flight Messages they generate and were grouped into one of three categories: small, medium, or large. The message data with the shortest frequency within each group was used as the inter-arrival time for the entire group. For each message, the average size and standard deviation is the same across all three groups regardless of the message source. The following sub-sections detail each of the 13 NAS Flight Messages.

3.3.6.1 Flight Plan Amendment

Flight Plan Amendment (AF) messages have a mean size of 72 Bytes, and a standard deviation of 6 Bytes. Figure 3-22 illustrates the size of AF messages throughout a sample day. As shown in the graph, the size of AF messages increases after 0500Z, peaks, and then decreases after 0900Z. With respect to frequency, the large data group has an inter-arrival time of 17 seconds with a standard deviation of 28 seconds, the medium data group has an inter-arrival time of 53 seconds with a standard deviation of 65 seconds, and the small data group has an inter-arrival time of 89 seconds with a standard deviation of 146 seconds. For visualization purposes, the frequency for all three groups is not shown in Figure 3-22. However, these numbers represent the peak frequency that was used in the SLAD for all three groups.

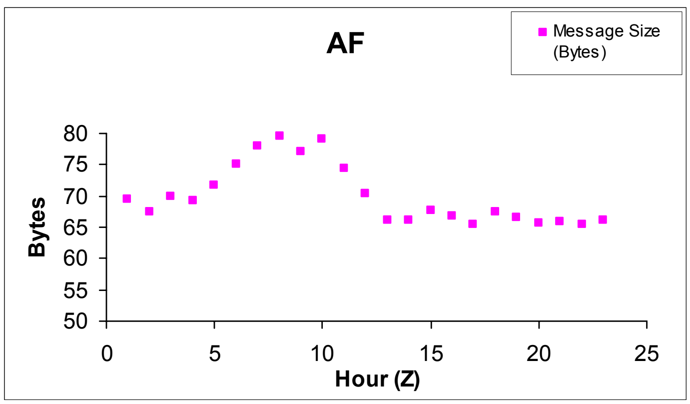


Figure 3-22: AF Message – Sample Day

3.3.6.2 Arrival Message

Arrival Messages (AZ) have a fixed size of 35 Bytes. With respect to the frequency, the large data group has an inter-arrival time of 50 seconds with a standard deviation of 47 seconds, the medium data group has an inter-arrival time of 109 seconds with a standard deviation of 169 seconds, and the small data group has an inter-arrival time of 144 seconds with a standard deviation of 227 seconds.

3.3.6.3 Beacon Code Message

Beacon Code Messages (BZ) have a fixed size of 38 Bytes. With respect to frequency, the large data group has an inter-arrival time of 13 seconds with a standard deviation of 8.7 seconds, the medium data group has an inter-arrival time of 30 seconds with a standard deviation of 36 seconds, and the small data group has an inter-arrival time of 43 seconds with a standard deviation of 46 seconds.

3.3.6.4 CZ Message

CZ messages have a mean size of 49 Bytes with a standard deviation of 15 Bytes. As shown in Figure 3-23, the size of CZ messages increases at approximately 0500Z and decreases at 0700Z. According to the data obtained, all three data groups have the same frequency. The frequency for all three data groups is an inter-arrival time of 1,058 seconds with a standard deviation of 1,136 seconds.

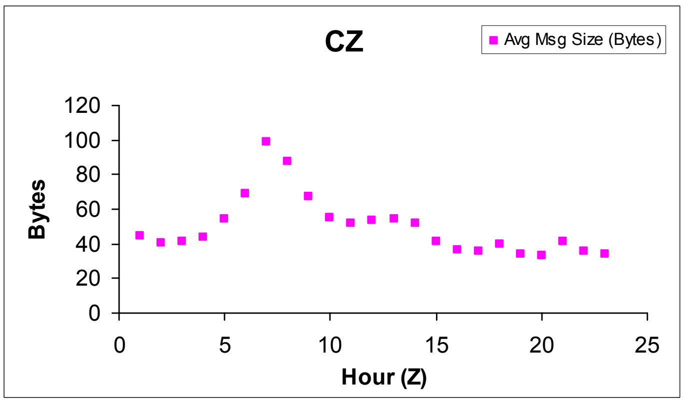


Figure 3-23: CZ Message – Sample Day

3.3.6.5 Departure Message

Departure Messages (DZ) have a mean size of 51 Bytes and a standard deviation of 4 Bytes. Unlike other NAS Flight messages, the size of these messages begins to decrease at 0500Z and increases again at approximately 0800Z. Figure 3-24 represents the size of DZ messages throughout a sample day. With respect to frequency, the large data group has an inter-arrival time of 55 seconds with a standard deviation of 62 seconds, the medium data group has an inter-arrival time of 111 seconds with a standard deviation of 181 seconds, and the small data group has an inter-arrival time of 180 seconds with a standard deviation of 266 seconds.

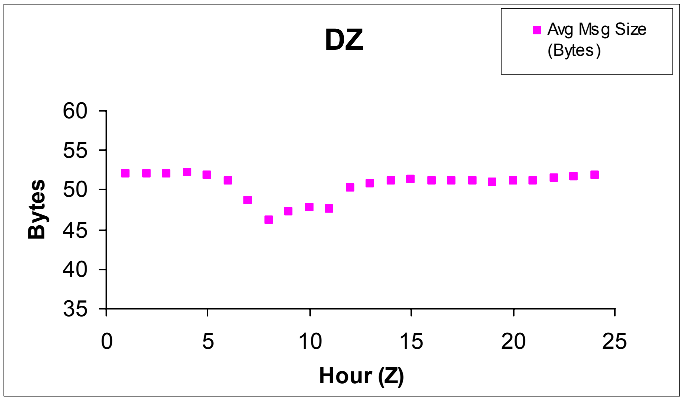


Figure 3-24: DZ Message – Sample Day

3.3.6.6 Scheduled Flight Message

Scheduled Flight Messages (FS) have a mean size of 103 Bytes and a standard deviation of 11 Bytes. Unlike other NAS Flight Data messages, as shown in Figure 3-25, FS messages change in size in the latter part of the day. Specifically, the size of these messages increases at 1500Z and peaks at 1900Z. The obtained data revealed that all three data groups have the same message frequency. The inter-arrival time across all of the groups is 5 seconds with a standard deviation of 4 seconds.

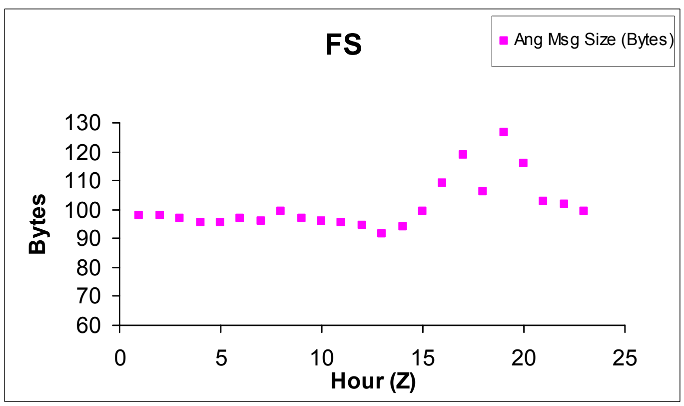


Figure 3-25: FS Message – Sample Day

3.3.6.7 Flight Plan Message

Flight Plan Messages (FZ) have a mean size of 105 Bytes and a standard deviation of 12 Bytes. Figure 3-26 represents the size of FZ messages throughout a sample day. With respect to frequency, the large data group has an inter-arrival time of 37 seconds with a standard deviation of 28 seconds, the medium data group has an inter-arrival time of 63 seconds with a standard deviation of 65 seconds, and the small data group has an inter-arrival time of 99 seconds with a standard deviation of 141 seconds.

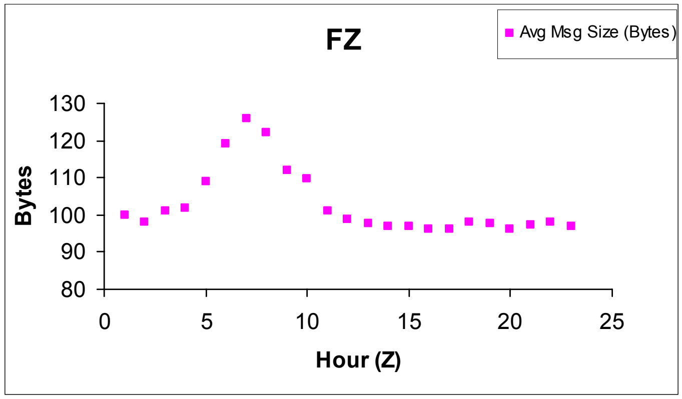


Figure 3-26: FZ Message – Sample Day

3.3.6.8 Scheduled Flight Cancellation Message

The size of Scheduled Flight Cancellation Messages (RS) remains fairly constant at 78 Bytes throughout the day. According to the data obtained, all three data groups have the same frequency. The inter-arrival time of RS messages has a mean of 947 seconds and a standard deviation of 980 seconds.

3.3.6.9 Flight Cancellation Message

Flight Cancellation Messages (RZ) have a mean size of 32 Bytes and a standard deviation of 4 Bytes. The following figure represents the size of RZ messages throughout a sample day. The frequency for the large data group of data has an inter-arrival time of 178 seconds with a standard deviation of 200 seconds, the medium data group has an inter-arrival time of 277 seconds with a standard deviation of 345 seconds, and the small data group has an inter-arrival time of 489 seconds with a standard deviation of 811 seconds.

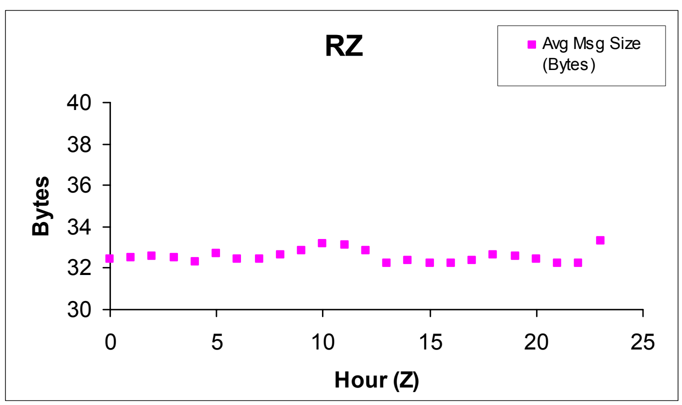


Figure 3-27: RZ Message – Sample Day

3.3.6.10 SQ Message

SQ Messages have a fixed size of 18 Bytes. According to the data obtained, all three data groups have the same frequency. The frequency for the three data groups has an inter-arrival time of 19.5 seconds with a standard deviation of 0.1 second.

3.3.6.11 Oceanic Position Update Message

Oceanic Position Update (TO) Messages have a mean size of 82 Bytes and a standard deviation is 4 Bytes. As shown in Figure 3-28, the peak periods are between 0200Z and 0500Z, and between 1300Z and 1500Z. The following figure represents the size of TO messages throughout a sample day. According to the data obtained, all three data groups have the same frequency. The frequency for the three data groups is an inter-arrival time of 17 seconds with a standard deviation of 7 seconds.

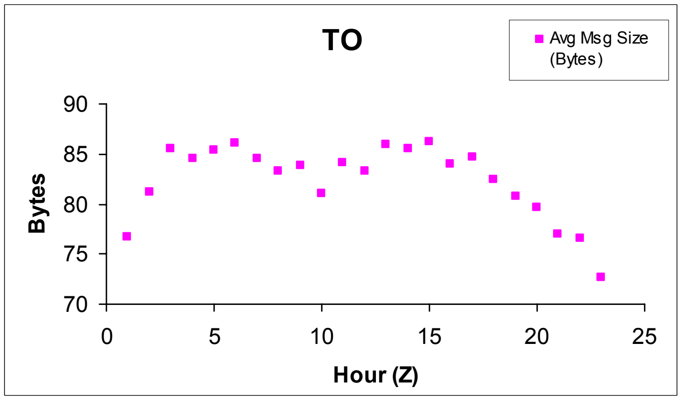


Figure 3-28: TO Message – Sample Day

3.3.6.12 Track Position Message

Unlike other flight data messages, Track Position Messages (TZ) are sent in groups instead of individually. Each TZ transmission has an average of 2 TZ messages. Each TZ transmission has a mean size of 95 Bytes and the standard deviation is 18 Bytes. With respect to frequency, the large data group has an inter-arrival time of 2.5 seconds with a standard deviation of 1.8 seconds, the medium data group has an inter-arrival time of 3.0 seconds with a standard deviation of 2.9 seconds, and the small data group has an inter-arrival time of 3.5 seconds with a standard deviation of 3.3 seconds.

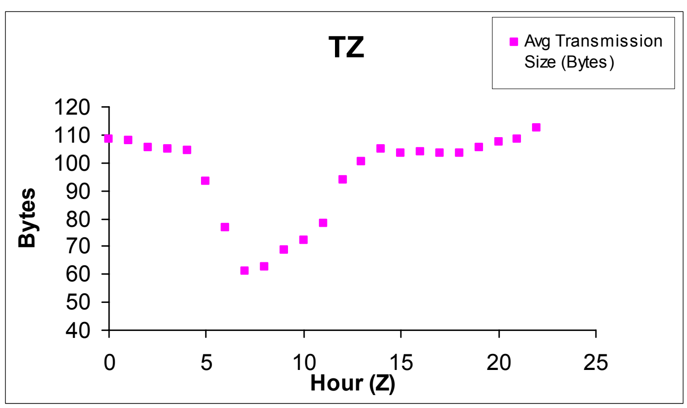


Figure 3-29: TZ Message – Sample Day

3.3.6.13 Boundary Crossing Message

Boundary Crossing Messages (UZ) have a mean size of 104 Bytes and a standard deviation of 5 Bytes. Similar to other NAS Flight Data messages, there is an increase in UZ message sizes between 0500Z and 1000Z.

Figure 3-30 represents the size of UZ messages throughout a sample day. With respect to frequency, the large data group has an inter-arrival time of 28 seconds with a standard deviation of 31 seconds, the medium data group has an inter-arrival time of 52 seconds with a standard deviation of 86 seconds, and the small data group has an inter-arrival time of 128 seconds with a standard deviation of 175 seconds.

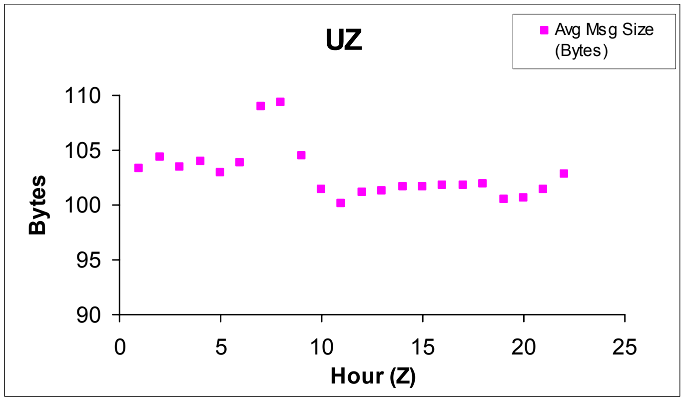


Figure 3-30: UZ Message – Sample Day

By examining the aggregate NAS Flight Data arriving at VNTSC, those messages that dominate NAS Flight Data traffic can be identified. The following figure shows the HATR of each NAS Flight Data message that is sent to VNTSC. As shown in Figure 3-31, TZ messages dominate the NAS Flight Data traffic. In addition, starting at 0000Z, there is a steady decrease of NAS Flight Data, which increases again after 0800Z. The peak occurs between 1700Z and 2300Z during a typical day.

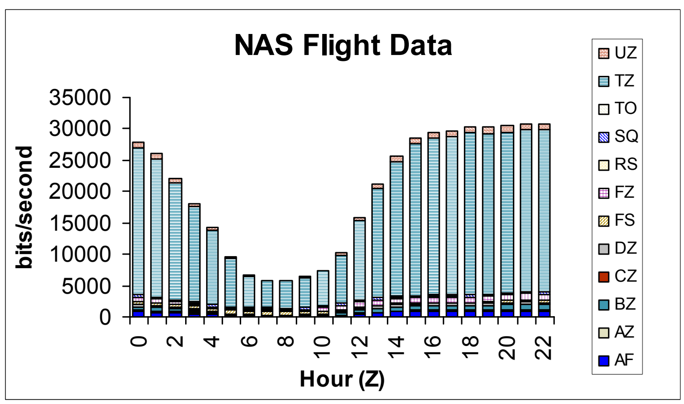


Figure 3-31: Hourly Average Traffic Rate of NAS Flight Data Messages – Sample Day